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November 30, 2018

Marlene H. Dortch Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20510

***Re: Supplemental Submission of the mmWave Coalition,* ET Docket No. 18-21, RM-11795**

Dear Ms. Dortch:

The mmWave Coalition ("mmWC" or the "Coalition") files this ex parte letter to provide the Commission with a more robust record in the above-captioned proceeding to make above-95 GHz spectrum more accessible and useful for innovative services and technologies.[1] As discussed further below, the public interest would be served by the Commission allocating larger-size blocks in bands above 95 GHz and creating greater regulatory certainty for approval of devices used for terahertz spectroscopy.

I. INTRODUCTION AND SUMMARY

The mmWC is a group of innovative companies and universities united in the objective of removing regulatory barriers to technologies using frequencies ranging from 95 GHz to 275 GHz. The Coalition does not limit itself to supporting any particular use or technology but rather it is working to create a regulatory structure in the United States for these frequencies that would encompass all technologies and all possible uses, limited only by the constraints of physics, innovation, and the imagination. A list of Members and principals of the Coalition are listed in an Attachment to these Comments. For more information, please visit http://mmwavecoalition.org/.

One of the primary benefits of spectrum bands above 95 GHz is the potential for wide-bandwidths unmatched in other bands allocated by the Commission. The mmWC urges that the Commission leverage this aspect of the band and create some bands above 95 GHz with available bandwidths of 20-40 GHz. One such band is the Japanese 116-138 GHz band. When considering

[1] Spectrum Horizons; James Whedbee Petition for Rulemaking to Allow Unlicensed Operation in the 95- 1000 GHz Band, ET Docket No. 18-21, RM-11795, Notice of Proposed Rulemaking and Order, FCC 18-17 (rel. Feb. 28, 2018) ("*NPRM*"); Comments of the mmWave Coalition, ET Docket No. 18-21, RM-11795 (filed May 2, 2018) ("mmWC Comments"); Reply Comments of the mmWave Coalition, ET Docket No. 18-21, RM-11795 (filed May 17, 2018) ("mmWC Reply Comments").

protection of passive services like radio astronomy and Earth Exploratory Satellite Service (EESS) systems, such protection should be focused on what is actually needed and should not impose burdens on the development of new technologies and new spectrum uses if such new uses can be shown to be compatible with the protected primary passive use.

Furthermore, the proposal set out in Appendix A to this letter, to amend footnote US246[2] both protects the scientific usage of the bands and allows the U.S. economy to benefit from innovative services in these bands.

Next, the mmWC requests that the Commission move expeditiously to develop rules to provide more regulatory certainty for approval of devices used for terahertz spectroscopy. There are products already being marketed in the U.S. for terahertz spectroscopy, but the current regulatory environment creates undue headwinds for introduction of such products. The Commission should not depend on an ill-defined "case-by-case " approach, which discourages capital formation for both R&D and manufacture of such equipment.

II. THE COMMISSION SHOULD OPEN LARGE SPECTRUM BLOCKS (MORE THAN 20 GHZ CONTIGUOUS ALLOCATIONS) ABOVE 95 GHZ

The main reason for using the spectrum above 95 GHz is to gain access to large blocks of contiguous bandwidth for either wideband communications and applications, or for short range sensing solutions, often called "terahertz spectroscopy."

In 2003, the Commission created three licensed bands of mmWave spectrum below 95 GHz.[3] These bands are set out in § 101.101 and listed in Table I below:

Table I: Licensed service bands authorized by the Commission in 2003

Band (GHz)	Total Bandwidth (GHz)
71-76	5.0
81-86	5.0
92-95	3.0

In the Commission's Spectrum Horizons NPRM,[4] the following bands are proposed to be made available for licensed service use:

[2] 47 CFR § 2.106 footnote US246.
[3] Allocations and Service Rules for the 71-76 GHz, 81-86 GHz and 92-95 GHz Bands, 18 FCC Rcd 23318 (2003).
[4] *NPRM* at ¶ 28.

Table II: Licensed Service bands proposed in NPRM

Band (GHz)	Total Bandwidth (GHz)
95-100	5.0
102-109.5	7.5
111.8-114.25	2.45
122.25-123	0.75
130-134	4.0
141-148.5	7.5
151.5-158.5	7.0
174.5-174.8	0.3
231.5-232	0.5
240-241	1.0

In Tables I and II, the bandwidth of each maximum channel size in the band is given. In the § 101.101 rules, there are two bands having 5.0 GHz bandwidth. In the *NPRM*'s proposed rules, there are three bands with bandwidths greater than or equal to 5.0 GHz, the largest of which are 7.5 GHz bands.

While we do not object to the proposed service rules for bands having bandwidths smaller than 5 GHz, those proposed rules are an artifact of allocation decisions that date back to the 1979 World Administrative Radio Conference before any technology was available for this spectral region.[5] A rational spectrum user needing 5 GHz of bandwidth would find it much easier and less expensive to build a system in the § 101.101 bands rather than in any of the bands above 95 GHz covered by the *NPRM*. Accordingly, in this proceeding, the mmWC respectfully requests that the Commission should create some spectrum allocations (e.g. contiguous bands) above 95 GHz with available bandwidths of 20-40 GHz, even if such bands have special coordination requirements to protect radio astronomy to protect and EESS systems.

Bandwidth allocations of 20-40 GHz provide an order of magnitude increase in available contiguous bandwidth for a particular service or allocation as compared to recent Commission allocations for 5G, and assure continued advancement in technology can enable capabilities commensurate with the leap in carrier frequency from the lower mmWave spectrum to bands above 95 GHz. In particular, it is worth noting that with recent 5G spectrum in the millimeter

[5] *See id.* ¶ 3, nn.2&3.

wave frequency bands having service allocations of several GHz (for example, from 37-40 GHz), providing allocations that are an order of magnitude larger at frequencies above 100 GHz is sensible and will spawn innovation in new imaging, communications, positioning, and other services not yet available in the mainstream.[6]

The proposals in the current *NPRM*[7] protect passive environmental satellites above 95 GHz through use of an allocation table mechanism developed decades ago that focuses on prohibiting all transmitters as the only possible protection mechanism for passive spectrum in frequencies ranging from 73 MHz to 252 GHz. While this total prohibition mechanism has had minimal adverse impact on other spectrum uses in the lower bands, the application of this same technique to bands above 95 GHz will preclude many potential valuable uses of that spectrum. Thus, while we agree with the need to protect these satellite systems, it is possible to achieve the needed protection without the adverse impact on terrestrial spectrum uses.

Several of the bands being considered in this proceeding are included in footnote US246 to the US Allocation Table[8] which reads:

> **US246** No station shall be authorized to transmit in the following bands: 73-74.6 MHz, 608-614 MHz, except for medical telemetry equipment and white space devices, 1400-1427 MHz, 1660.5-1668.4 MHz, 2690-2700 MHz, 4990-5000 MHz, 10.68-10.7 GHz, 15.35-15.4 GHz, 23.6-24 GHz, 31.3-31.8 GHz, 50.2-50.4 GHz, 52.6-54.25 GHz, 86-92 GHz, 100-102 GHz, 109.5-111.8 GHz, 114.25-116 GHz, 148.5-151.5 GHz, 164-167 GHz, 182-185 GHz, 190-191.8 GHz, 200-209 GHz, 226-231.5 GHz, 250-252 GHz. (Footnotes omitted)

While the 10 bands listed in US246 cover only 33.35 GHz out of the 180 GHz between 95-275 GHz, or 18.5% of the total bandwidth, their adverse impact on introduction of new technologies is much greater than implied by this percentage because the "no use" frequency stipulations fragment the spectrum into many small contiguous bands. While the industry works on aggregating non-contiguous blocks of spectrum above 95 GHz, we believe that making large contiguous blocks available would simplify the initial design of these systems and attract more investment.

Table III below shows the US246 bands above 95 GHz, the bandwidth of each band, as well as the interstitial spacing among the US246 bands.

[6] Prof. Theodore Rappaport, NYU WIRELESS, Future Wireless Technologies: MmWave, THz, and beyond (Sept. 27, 2018), available at https://wireless.engineering.nyu.edu/presentations/THz-mmWave-coalition.pdf. ("Rappaport Presentation").

[7] *NPRM* at Appendix A.

[8] 47 C.F.R. § 2.106.

Table III: US246 Bands and Their Implications for Other Services

Lower Band Edge (GHz)	Upper Band Edge (GHz)	Bandwidth (GHz)	Non-US246 Bandwidth to Next US246 Band (GHz)
100	102	2	7.5
109.5	111.8	2.3	2.45
114.25	116	1.75	32.5
148.5	151.5	3	12.5
164	167	3	15
182	185	3	5
190	191.8	1.8	8.2
200	209	9	17
226	231.5	5.5	18.5
250	252	2	

Even without modifying US246, there are 32.5 GHz of spectrum available without a present transmitter prohibition between 116 and 148.5 GHz. This includes the 116-134 GHz band that has been available to users in Japan since 2014.[9]

There are ways to accommodate sensors without unduly impacting other services. Because there is substantial interest in the 120 GHz band for sensing application, the same device (mobile or otherwise) using 120 GHz sensing will also potentially use bands around 120 GHz (avoiding 120 GHz for interference) for communication. Opening the full range of 116-148.4 GHz for communication use would help justify a business case for their R&D in this spectral range since it would be easier to segment this range between multiple uses.

Similarly, there is substantial interest in the 240 GHz range for auto radar applications. Opening the whole range of 231.5-250 GHz for communication use would allow use for auto radar and communication.

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[9] *NPRM* at ¶ 12. The National Frequency Allocation of Japan, available at http://www.tele.soumu.go.jp/resource/e/search/share/pdf/t3.pdf, identifies this band for "Commercial Telecommunications Service" as well as for "Public Service."

There is also substantial work being done to standardize uses above 250 GHz. Specifically, there has been as standard created recently in IEEE 802.15.3d for global Wi-Fi use at frequencies above 250 GHz and is likely to first be used in the 252 to 275 GHz spectrum bands. The new IEEE 802 standard supports wireless switched point-to-point physical layer connectivity as a part of IEEE 802.15.3, with a nominal PHY data rate of 100 Gbps with fallbacks to lower data rates, as needed. IEEE 802.15.3d-2017[10] is defined for the spectrum in the 252 GHz to 325 GHz range, with coverage distances as short as a few centimeters, as well as longer connections as point-to-point links up to several hundreds of meters.

Additionally, modifications to the Medium Access Control (MAC) layer in IEEE 802.15.3d will enable the new IEEE 802.15.3d-2017 PHY layer to target applications such as the "Information Shower,"[11] intra-device communication, wireless fiber for backhaul, and connectivity in data centers and massive computer installations. The IEEE 802.15.3d-2017 standard was approved on September 28, 2017 and was published on October 12, 2018 as the worldwide first wireless communications standard for the 250 – 350 GHz frequency range.

III. THE COMMISSION SHOULD AMEND FOOTNOTE US246 TO STILL PROTECT SCIENTIFIC USE OF THE BANDS WHILE ALLOWING INNOVATIVE USE OF THESE BANDS

Footnote US246 is overly protective, and an undue impediment to innovation above 95 GHz, due to its bright line prohibition on transmissions in valuable spectrum ranges. There is nothing in the *NPRM* or the record of this proceeding to date that explains why the "No station shall be authorized to transmit" provision of US246 is considered necessary for spectrum above 95 GHz, or that an outright prohibition is the only possible mechanism that adequately protects other allocations. The simple fact is that outright prohibition stifles innovation. On the other hand, opening the door to spectrum use with carefully designed protection mechanisms promotes technical innovation and encourages entrepreneurship. Indeed, the benefits of this innovation and entrepreneur-friendly approach are recognized in US246 itself, which contains two later addition footnotes permitting certain limited communications uses in specified bands under conditions that protect the primary passive use of the bands.

The two charts in Figure 1 and 2 show the impact of US246 and how the prohibitions in that provision disproportionately impacts the spectrum at Extremely High Frequencies (EHF).

[10] IEEE Standard for High Data Rate Wireless Multi-Media Networks, Amendment 2: 100 Gb/s Wireless Switched Point-to-Point Physical Layer, https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=8066476.

[11] T. S. Rappaport, R. W. Heath, R. Daniels, J. Murdock, "Millimeter Wave Wireless Communications," Pearson, c. 2015.

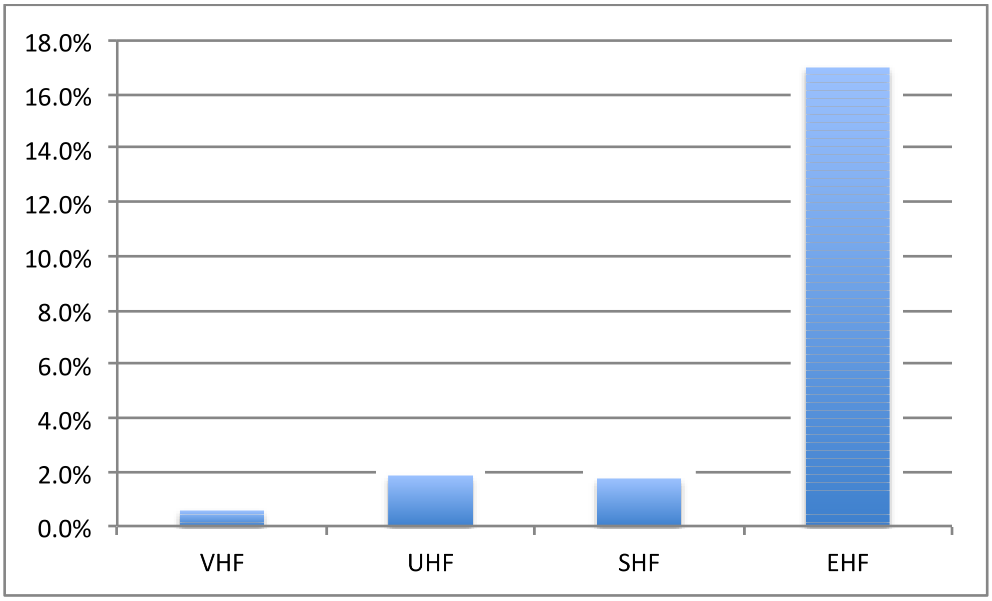

Figure 1: Fraction of spectrum band covered by US246 "no transmission" rules

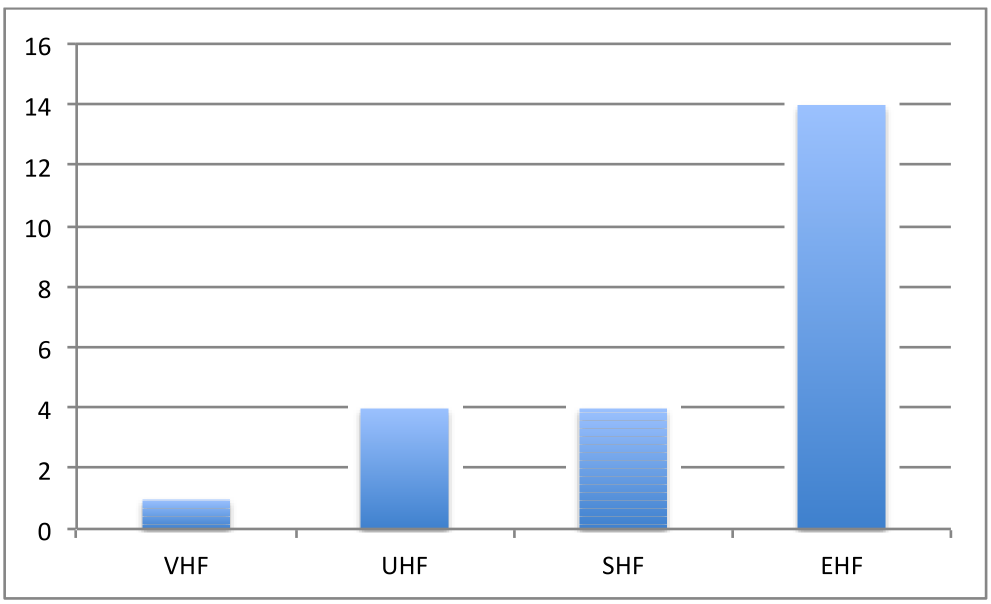

Figure 2: Number of contiguous spectrum blocks covered by US246 "no transmission" rules

mmWC fully supports the use of spectrum for passive scientific uses. The Radio Astronomy Service (RAS) is not an issue here, as such facilities in the spectrum covered by the *NPRM* need high, arid locations for optimum performance and there are few such facilities in the U.S. The National Academy of Sciences Committee on Radio Frequencies ("CORF") lists in its comments seven such facilities, existing or planned, in the U.S.[12] The two facilities located east of the Mississippi

[12] Comments of The National Academy 0f Sciences' Committee on Radio Frequencies, Docket No. ET 18-21, et al. (filed March 30, 2018), at p. 14 ("Comments of CORF").

River both operate only up to 116 GHz. RAS can usually be protected by coordination of users with the RAS community since siting and azimuth of FS systems are key factors that determine whether sharing is possible. Thus, RAS protection for Part 101 systems usually involves retractions on pointing directions in small fractions of U.S. territory, not major restrictions on spectrum use.

EESS sharing is more difficult because NGSO satellites observe the earth and its atmosphere from various orbits and at various orbital heights and have very sensitive sensors.[13]

Propagation at frequencies above 95 GHz, however, is very different from propagation in lower bands, due both to atmospheric absorption and the use of highly directional antennas to overcome free space loss.[14] The *NPRM* contains in Figure 1 "Specific Attenuation Due to Atmospheric Gases." Basically, atmospheric molecules absorb radio power similar to the way water (and fat) molecules in a home microwave oven absorb 2.4 GHz power and turn it into heat. While the power levels involved in communications systems at these frequencies do not transfer much heat into atmospheric molecules, the net effect is still the same and results in an exponential decrease of power from a transmitter with distance. This decrease lessens with higher altitude since pressure/density of gases decreases with altitude. The ITU-R P. 676-11 propagation model can be used to calculate losses at different altitudes.[15] Figure 3, below, shows the approach this model uses to compute path loss over a path of varying altitudes but using ray tracing to calculate short segments and the associated loss for each.

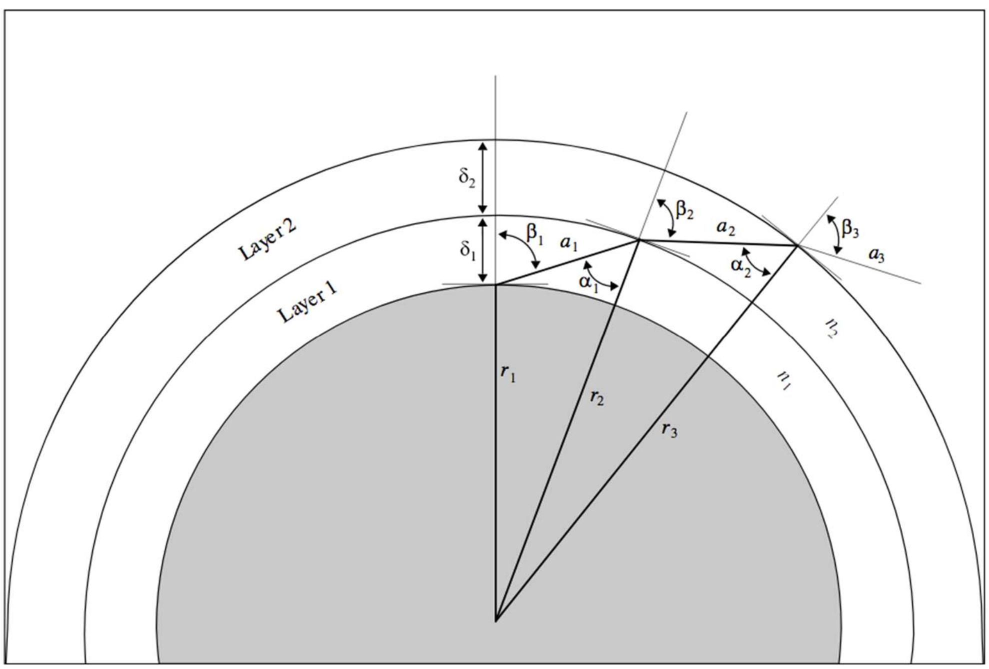

Figure 3: Ray tracing approach used by ITU-R P. 676-11 propagation model to compute path loss over varying altitude paths

[13] National Research Council. 2010. *Spectrum Management for Science in the 21st Century*. Washington, DC: The National Academies Press, Available at https://doi.org/10.17226/12800.

[14] Rappaport Presentation at 7-11.

[15] ITU-R Recommendation P.676-11 (09/2016), Attenuation by atmospheric gases (https://www.itu.int/rec/R-REC-P.676-11-201609-I/en).

Using this model, with software provided by NASA, we computed the path loss from a terrestrial transmitter with a horizontal path to typical orbit locations of EESS systems as shown below:

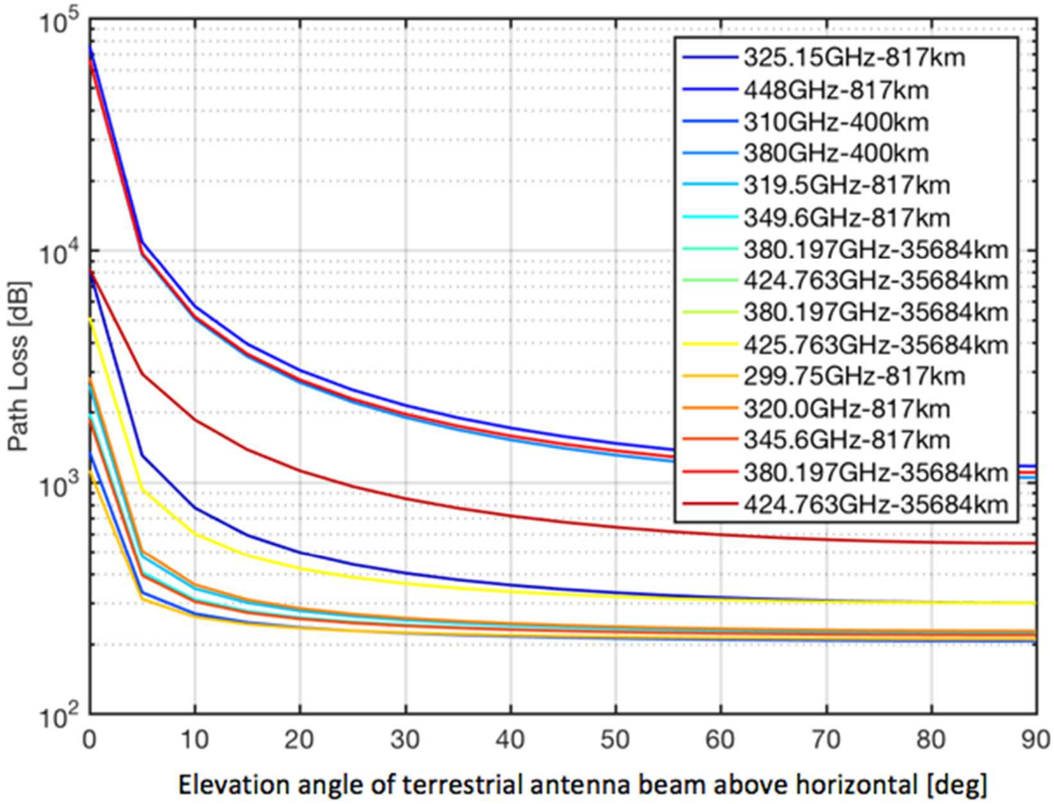

Figure 3: Path loss from terrestrial FS links to NGSO EESS locations[16]

At low elevation angles, where satellites are viewed "on the horizon" from earth, it is readily seen that the path losses are very large, exceeding 1000 dB near 0 degrees. However, at high angles approaching zenith (e.g. "overhead"), absorption becomes insignificant and the path losses can be in the 200dB range due to distance, comparable to typical satellite path losses in much lower bands.

In the U.S. preparation for WRC-19 Agenda Item 1.15 with regard to 275-450 GHz, it became apparent that a key concern of NASA, as the principal proponent of EESS, was the sidelobe levels they expected from Fixed Service transmitters at high elevation angles and which they assumed were consistent with ITU-R F.699-8.[17] However, ITU-R F.699-8, even in the latest 2018 version, deals only with frequencies up to 86 GHz and is focused on interference among terrestrial systems

[16] Computation from Prof. Josep Jornet, Zahed Hossein and Priyangshu Sen, University at Buffalo, SUNY.
[17] ITU-R Recommendation F.699-8 (01/2018), Reference radiation patterns for fixed wireless system antennas for use in coordination studies and interference assessment in the frequency range from 100 MHz to 86 GHz, available at https://www.itu.int/dms_pubrec/itu-r/rec/f/R-REC-F.699-8-201801-I!!PDF-E.pdf.

using current commercial production antennas. NASA does not claim to show performance limits for new antennas or even performance limits for commercially practical antennas.

mmWC believes that nontraditional antenna designs, for example using quasi optical approaches, are possible and likely for the spectrum above 95 GHz, and that the absolute prohibition of US246 should be replaced with a performance-based restriction that protects critical scientific uses while allowing the development of new technologies to use spectrum more efficiently.

If there is a regulatory incentive to develop high performance antennas, it is reasonable to expect that the R&D marketplace will respond to the Commission changing the protection model for EESS from an absolute prohibition to a performance-based limit. Thus, we propose that the Commission revise US246 as proposed in Appendix A to this letter, as a mechanism both to protect critical EESS receivers and to encourage responsible sharing through creative design of terrestrial systems to coexist with passive systems and thus enable use of large spectrum blocks including both US246 bands and bands that are presently allocated for terrestrial Fixed Service use.

Our US246 proposal set out in Appendix A includes a variety of safeguards for EESS:

- All licenses or assignments by the Commission and NTIA must assure that, individually and in aggregate with other users, EESS systems are protected within current ITU-R criteria
- In order to handle technical evolution of EESS systems, as soon as the Commission, NTIA and State Department agree to a US position proposing a change to any of the cited criteria, that proposed change becomes the criteria for the Commission and NTIA licenses or assignments as long as the proposed change is still pending in ITU-R.

We propose retaining the present provisions of US246 below 100 GHz. While the choice of 100 GHz is a bit arbitrary, there are real reasons for a dichotomy here. Lower frequencies have longer wavelengths which may greatly complicate high suppression levels for sidelobes in practical sized antennas. In addition, low frequencies are vulnerable to anomalous propagation that can enhance greater propagation distances for a given power level - various intermittent weather or ionospheric condition-related phenomenon, *e.g*. ducting and sporadic E propagation, that sometimes greatly extend normal propagation distances. In addition, as Figures 1 and 2 show, the impact of present US246 policies at lower bands is much less severe due to the small density of bands and small fraction of spectrum covered with US246 prohibitions.

While we can find no documentation on why US246 and its ITU counterpart, Footnote 5.340, were originally adopted, we do not think the present wording is reasonable for systems above 95 GHz. Further, the current regulation imposes excessive burdens on other radio services, and such burdens are unnecessary for protection of the passive services in this upper spectrum. In its comments in response to the current *NPRM*, the CORF, on behalf of the scientific users of passive spectrum, concluded with this statement: "CORF generally supports the sharing of frequency allocations, where practical, but protection of passive scientific observations, as discussed herein, must be addressed."[18]

We agree fully that passive scientific uses of spectrum must be protected, but that protection should be focused on what is actually needed and should not impose unreasonable burdens

[18] Comments of CORF at 30.

that stymie the development or investment in discovery of new technologies and new spectrum uses, if such new technologies and spectrum usage can be shown to be compatible with the protected primary passive use. The mmWC proposal set out in Appendix A both protects the scientific usage of the bands and allows the U.S. industrial complex to earnestly research and develop technologies that could provide innovative services that would bring benefit to the US economy in these bands.

The Commission notes in the *NPRM* that in 2014 "Japan's Ministry of Internal Affairs and Communications officially revised its radio regulations to allocate an 18 gigahertz-wide band at 116 GHz to 134 GHz to accommodate (ENG)."[19] Yet there is neither a proposal to have service rules for a similar bandwidth, nor an explanation of why such an allocation is not possible in the U.S. The only bands of comparable bandwidth that are even mentioned (although not actually proposed) in the *NPRM* for use in the U.S. are both above 209 GHz - a much further stretch for today's technology development efforts. There seems to be no reason to deny access to large bandwidths to prospective users in the U.S., particularly given the enormously high path loss values shown in Figure 3 for wireless devices that would radiate on the horizon (e.g. at very low slant angle).

Table IV: US Allocation Table for 116-134 GHz band used in Japan since 2014

116-122.25 EARTH EXPLORATION-SATELLITE (passive) INTER-SATELLITE 5.562C SPACE RESEARCH (passive) 5.138 5.341 US211		ISM Equipment (18)	
122.25-123 FIXED INTER-SATELLITE MOBILE 5.558 5.138	122.25-123 FIXED INTER-SATELLITE MOBILE 5.558 Amateur 5.138	ISM Equipment (18) Amateur Radio (97)	Band proposed for Part 101 in NPRM
123-130 FIXED-SATELLITE (space-to-Earth) MOBILE-SATELLITE (space-to-Earth) RADIONAVIGATION RADIONAVIGATION-SATELLITE Radio astronomy 5.554 US211 US342			
130-134 EARTH EXPLORATION-SATELLITE (active) 5.562E FIXED INTER-SATELLITE MOBILE 5.558 RADIO ASTRONOMY 5.562A US342			Band proposed for Part 101 in NPRM

The Allocation Table (Table IV, included above) shows in the 3rd column ISM equipment designations for both 116-122.25 and 122.5-123 GHz. A more detailed reading of Part 18

[19] *NPRM* at ¶ 12.

shows that §18.301 currently states that 122.5 GHz ±500.0 MHz, or 122-123 GHz, is allocated as an "operating frequency" for use by ISM equipment. Pursuant to § 18.305, "ISM equipment operating on a frequency specified in §18.301 is permitted unlimited radiated energy in the band specified for that frequency."[20]

ISM equipment, whether or not it has a primary frequency in this band, is allowed to operate with field strengths specified in § 18.305(b), especially since this is not a § 18.303 "prohibited frequency band." Thus, any EESS system in 116-122.25 GHz may operate *today* with unlimited terrestrial ISM signals in the top 250 MHz of the band and with signals at the § 18.305(b) limits in the rest of the band. There is no explanation of why Part 101 systems that expose the satellite to the same signal level would be unacceptable to EESS systems.

While there is an EESS allocation in 116-122.5 GHz, this is an ordinary co-primary allocation without special protection from either US246 or the related ITU footnote 5.340. Thus, the Commission is free to make any domestic allocation in this band, provided it protects the primary allocation through the provisions of its technical rules. This band lacks any special US246 "wilderness area" protections.

We can understand the lack of a proposal for 116-122.25 GHz, but urge an investigation regarding 123-130 GHz, part of the band used in Japan, which will require more information on the record about the nature of the services that the Commission is trying to protect in this band.

IV. THE COMMISSION SHOULD PROVIDE REGULATORY CERTAINTY FOR APPROVAL OF DEVICES FOR TERAHERTZ SPECTROSOPY

The *NPRM* states, "[w]e are aware of interest in using the spectrum above 95 GHz for devices that use terahertz spectroscopy to analyze material properties and for imaging applications, which could possibly be considered ISM applications."[21] However, the situation is advanced beyond just "interest." There are products being marketed in the U.S. for terahertz spectroscopy. Indeed, a milestone in the commercialization of terahertz spectroscopy was R&D investment by NASA to use such technology to address critical Space Shuttle Program safety issues in both fuel tank insultation[22] and adhesion of heat resistant tiles to the Space Shuttle that were critical for safe reentry.[23]

The comments of TeraMetrix are clear on their present participation in marketing of this technology today:

> TeraMetrix is based in Ann Arbor, Michigan, and is a division of Luna Innovations, Inc. (NASDAQ LUNA) of Roanoke, Virginia. TeraMetrix employs approximately 25 people in its Ann Arbor factory. TeraMetrix markets and sells commercial time domain terahertz instrumentation for industrial process

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[20] 47 C.F.R. § 18.305.

[21] *See NPRM* at ¶ 61.

[22] D. Zimdars, J. S. White, G. Stuk, A. Chernovsky, G. Fichter, and S. Williamson, “Large area terahertz imaging and non-destructive evaluation applications,” Insight, vol. 48, no. 9, pp. 537–537, 2006;D. Zimdars, "Technology and Applications of Terahertz Imaging Non-Destructive Examination: Inspection of Space Shuttle Sprayed On Foam Insulation".2005, available at https://www.researchgate.net/publication/253386662_Technology_and_Applications_of_Terahertz_Imaging_Non-destructive_Examination_Inspection_of_Space_Shuttle_Sprayed_On_Foam_Insulation.

[23] NASA Orbiter Project Office, Terahertz NDE Application for Corrosion Detection and Evaluation under Shuttle Tiles, available at https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20070016023.pdf.

> monitoring and control; non-destructive imaging; and research and development spectroscopy.... Since 2012, our T-Ray 5000 series of "T-Gauge" instrumentation has been deployed worldwide by industry, academia, the U.S. D.O.D., and NASA.[24]

They further state that their terahertz spectroscopy equipment is used:

> for industrial online factory process monitoring and control by measuring multi-layer thickness of extruded plastics; multi-layer thicknesses of paints (including wet paint); basis weight; density; delamination and moisture. TeraMetrix's time domain terahertz gauges are deployed worldwide in factories that make tires, rubber, building products, paper, plastic pipe, coated steel pipe, blow molded bottles, aircraft coatings, fuel tanks, and many other products. As a nondestructive imaging device, TeraMetrix imagers are/have been used to image the Space Shuttle external tank, the Space Shuttle thermal protection system, Orion spacecraft thermal protection system, military aircraft coatings, military ship coatings, radomes, food, pharmaceuticals, and other products.[25]

The *NPRM* contains the statement that "the Office of Engineering and Technology currently evaluates applications for devices that use the frequencies above 95 GHz on a case-by-case basis,"[26] and the related footnote (fn. 151) cites "Knowledge Database (KDB) Publication 227764" in support of this statement. This publication, however, provides no guidance on what criteria to use to authorize the devices designed for terahertz spectroscopy that use the frequencies above 95 GHz.

Developers and manufacturers cannot be expected to spend large amounts of resources on innovative technologies with no guidance at all from the agency on what criteria are used to approve the technology for market access.

In summary, terahertz spectroscopy has been marketed to both commercial users and federal agencies for more than a decade. The users of terahertz spectroscopy equipment apparently bought it with a well-justified view that it was permitted under current Part 18 rules. mmWC asks that the Commission move expeditiously to develop rules that establish a more certain regulatory approach for devices designed for terahertz spectroscopy that use the frequencies above 95 GHz. The Commission should not depend on an ill-defined "case-by-case " approach, which discourages capital formation for both R&D and manufacture of such equipment.

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[24] Comments of TeraMetrix, a Division of Luna Innovations, Inc., ET Docket No. 18-21 (filed May 15, 2018), at 1.
[25] *Id.* at 1-2.
[26] *NPRM* at ¶ 61.

Through this submission, the mmWave Coalition respectfully requests that the Commission take action as recommended above to establish rules that facilitate the introduction of innovative services and technologies in the above-95 GHz frequency bands.

Respectfully submitted,

mmWAVE COALITION

/s/Prakash Moorut

By: Prakash Moorut
Chair of Steering Group
mmWave Coalition

APPENDIX A

PROPOSED ALTERNATIVE TO US246 IN THE FCC'S TABLE OF REGULATIONS

US246 No station shall be authorized to transmit in the following bands: 73-74.6 MHz, 608-614 MHz (except for medical telemetry equipment[1] and white space devices),[2] 1400-1427 MHz, 1660.5-1668.4 MHz, 2690-2700 MHz, 4990-5000 MHz, 10.68-10.7 GHz, 15.35-15.4 GHz, 23.6-24 GHz, 31.3-31.8 GHz, 50.2-50.4 GHz, 52.6-54.25 GHz, 86-92 GHz.

In 100-102 GHz, 109.5-111.8 GHz, 114.25-116 GHz, 148.5-151.5 GHz, 164-167 GHz, 182-185 GHz, 190-191.8 GHz, 200-209 GHz, 226-231.5 GHz, 250-252 GHz, all stations are generally forbidden; however, the Commission and NTIA will issue licenses or assignments only under mutually agreed procedures that assure that authorized Radio Astronomy Service facilities and Earth Exploration Satellite Service stations are protected from both the individual and aggregate emissions to the criteria given in ITU-R RS.2017, ITU-R RS.1858, ITU-R RA.517, ITU-R RA.517, ITU-R RA.611, ITU-R RA.769-2 and ITU-R RA.1031. In cases where there is a formal coordinated Commission/NTIA/DOS US proposal to ITU-R to adopt a stricter standard protection limit, that draft position will apply as long as the draft is pending in ITU-R.

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[1] Medical telemetry equipment shall not cause harmful interference to radio astronomy operations in the band 608-614 MHz and shall be coordinated under the requirements found in 47 CFR 95.1119.

[2] White space devices shall not cause harmful interference to radio astronomy operations in the band 608-614 MHz and shall not operate within the areas described in 47 CFR 15.712(h).

ATTACHMENT: MEMBERS AND PRINCIPALS OF THE MMWAVE COALITION

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Founder and Director

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Jeremy Tole
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